Electrodynamic Propulsion Operations Beyond the Ionosphere

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ABSTRACT

In the classical concept for the operation of electrodynamic propulsion in space, a voltage is applied across a tether—either by the electromotive force created by the tether's orbital motion through the earth's planetary magnetic field, or by a power supply. Electrons are then collected from the ionospheric plasma at the positive pole and actively emitted back into space at the negative pole; thereby creating an electrical current in the tether. This physical circuit is closed by return currents driven through the ambient conducting ionosphere.

This concept has been proven to work in space by the TSS-1, TSS-1R, and PMG tether flight experiments. However, because of the dependence on ionospheric conductivity, electrodynamic tether operations are limited to the F-region of the ionosphere where the plasma density is sufficient to conduct the required return currents—in other words, between altitudes of approximately 300 to 1200 km in sunlight. In the earth's shadow, the ionospheric density drops precipitously and tether operations, using the above approach, are not effective—even within this altitude range.

High Δv missions that require in-space propulsion outside of the above conditions at Earth—or in any region of space containing a planetary magnetic field—would be greatly enhanced by the very high ISP capabilities of electrodynamic propulsion. The subject of this presentation will be a revolutionary concept that would eliminate the need to collect electrons from the ionosphere. Because this would make operations virtually independent of any ambient plasma, electrodynamic propulsion could be used virtually anywhere within the magnetosphere; extending the operational range into the earth's shadow and out to synchronous orbit—forty times the present operational range at earth. The benefit at the outer planets, with their huge magnetospheres, would be correspondingly greater.

The key to this concept is the active generation of plasma and *emission* of charge at each pole of the tether so that current generation does not depend on electron collection from the ambient ionosphere. Arguments will be presented, based on existing flight data, which show that bi-polar charge emissions can be achieved in space. The open question is the amplitude of the resulting current. If sufficient current can be sustained, the classical long and dynamic tether can be replaced with a deployable boom that is rigid and shorter, thereby circumventing a number of tether-specific problems. Moreover, this architecture would also significantly lower dynamic drag, making electrodynamic operations at lower altitudes possible.